

What is claimed is:

1. A method of knotting an end lacing terminal of a cord used for wrapping a generally toroidal coil of a dynamo-electric machine, by means of a lacing apparatus of the type comprising cord supply means, a lacing needle having a hook-shaped extremity and capable of rotating around its axis as well as of moving radially and axially relatively to said coil for engaging said cord and pulling it radially in order to form interlaced lacing rings wrapping said coil, and means for rotating said coil around its axis in synchronism with the movements of said needle, the method comprising the steps of:

forming, upon completion of a lacing phase, a plurality of knotting rings in a chain-like arrangement on said end lacing terminal, by making the cord pass each time through a previously formed knotting ring or through a last-formed lacing ring, respectively, when a first knotting ring is being formed; and

cutting the last knotting ring of said plurality;
wherein said forming step comprises, during the formation of each knotting ring, pulling the cord to such an extent that said last-formed lacing ring and respectively each knotting ring preceding a last knotting ring in the chain are individually closed on the knotting ring being formed, whereby a chain of knot lockups forming a self-locking knot is obtained.

2. The method according to claim 1, wherein said knotting rings are formed through the steps of:

(a) once finished the lacing phase by means of a last radial movement of the needle from the inside of the coil toward the outside to form said last lacing ring, separating the synchronism between the rotation movement of the coil and

the movement of the needle and stopping the rotation of said coil;

(b) driving the needle in a first radial movement toward the inside of the coil, along a path equivalent to a needle path during said last radial movement, but in opposite direction;

(c) hooking the cord, supplied by said cord supplying means, by means of the hook-shaped extremity of said needle;

(d) driving the needle with the cord engaged in its hook-shaped extremity in a first radial movement toward the outside of the coil, along a path equivalent to the needle path during said first radial movement toward the inside, but in opposite direction, pulling the cord into said last lacing ring, causing its closing into a first knot lockup and forming the first knotting ring;

(e) driving the needle in a second radial movement toward the inside of the coil, along a path equivalent to the needle path during said last radial movement, but in opposite direction;

(f) hooking the cord, supplied by said cord supplying means, by means of the hook-shaped extremity of said needle;

(g) driving the needle, with the cord engaged in its hook-shaped extremity, in a second radial movement toward the outside of the coil, along a path equivalent to the needle path during said second radial movement toward the inside, but in opposite direction, pulling the cord into said first knotting ring, causing its closing into a second knot lockup and forming a second knotting ring; and

(h) executing a cut in the last knotting ring and pulling the cord for extracting the free extremity, obtaining consequently a self-locking knot.

3. The method according to claim 2, wherein, before executing the cut in said second knotting ring, the following steps are accomplished:

(a) driving the needle in a third radial movement toward the inside of the coil, along a path equivalent to the needle path during said last radial movement, but in opposite direction;

(b) hooking the cord, supplied by said cord supplying means, by means of the hook-shaped extremity of said needle; and

(c) driving the needle, with the cord engaged in its hook-shaped extremity, in a third radial movement toward the outside of the coil, along a path equivalent to the needle path during said third radial movement toward the inside, but in opposite direction, pulling the cord into said second knotting ring, causing its closing into a third knot lockup and forming a third knotting ring.

4. The method according to claim 2, wherein, before executing the cut in said second knotting ring, the steps are repeatedly iterated in order to form a chain having a desired length.

5. The method according to claim 4, wherein the needle, after having hooked the cord, performs a rotation by about 180° around its axis, during the radial movement toward the outside of the coil, turning downwards its hook-shaped extremity.

6. The method according to claim 5, wherein the needle, after having done a radial movement toward the outside of the coil, performs a rotation of about 180° around its axis turning up again its hook-shaped extremity.

7. The method according to claim 5, wherein the needle, after having done a radial movement toward the outside of the coil, effects a first axial movement downwards, a rotation by about 180° around its axis, turning up again its hook-shaped
5 extremity, and a second axial movement upwards in a direction opposite to said first axial movement.

8. The method according to claim 1, wherein said knotting rings are formed through the steps of:

10 (a) once finished the lacing phase by means of a last radial movement of the needle from the inside of the coil toward the outside to form said last lacing ring, separating the synchronism between the rotation movement of the coil and the movement of the needle and stopping the rotation of said coil;

15 (b) driving the needle in a first rotation around its own axis, to form a first torsion in said last lacing ring and obtain a twisted last lacing ring;

20 (c) driving the needle in a first radial movement toward the inside of the coil, along a path equivalent to the needle path during said last radial movement, but in opposite direction;

(d) hooking the cord, supplied by said cord supplying means, by means of the hook-shaped extremity of said needle;

25 (e) driving the needle, with the cord engaged in its hook-shaped extremity, in a first radial movement toward the outside of the coil, along a path equivalent to the needle path during said first radial movement toward the inside, but in opposite direction, pulling the cord into said twisted last lacing ring, causing its closing into a first knot lockup and
30 forming a first knotting ring; and

(f) executing a cut in the last knotting ring and pulling the cord for extracting the free extremity, obtaining consequently a self-locking knot.

5 9. The method according to claim 8, wherein, before executing the cut in the last knotting ring, the following steps are accomplished:

10 (a) driving the needle in a second rotation around its own axis to form a second torsion in said first knotting ring and obtain a first twisted knotting ring;

 (b) driving the needle in a second radial movement toward the inside of the coil, along a path equivalent to the needle path during said last radial movement but in opposite direction;

15 (c) hooking the cord, supplied by said cord supplying means, by means of the hook-shaped extremity of said needle; and

20 (d) driving the needle, with the cord engaged in its hook-shaped extremity, in a third radial movement toward the outside of the coil, along a path equivalent to the needle path during said second radial movement toward the inside, but in opposite direction, pulling the cord into said first twisted knotting ring, causing its closing into a second knot lockup and forming a second knotting ring.

25 10. The method according to claim 9, wherein said first rotation is performed in a direction opposite to the direction of said second rotation.

30 11. The method according to claim 9, wherein said first and said second rotations are rotations by about 540°.

 12. The method according to claim 8, wherein, before executing the cut in the last knotting ring, the steps (b),

(c), (d) and (e) are repeatedly iterated, in order to form a twisted ring chain having a desired length.

13. The method according to claim 8 or 9 or 12, wherein the needle, after having done one of said radial movements
5 toward the outside of the coil, effects a first axial movement downwards and, after a rotation around its axis, effects a second axial movement upwards moving in the upper position.

14. The method according to claim 2 or 8, wherein, before executing the cut in the last knotting ring, the
10 following steps are accomplished:

(a) driving the needle in a first radial movement toward the inside of the coil passing through the last knotting ring; and

(b) hooking the cord by means of a harpoon that comes
15 from a side direction substantially perpendicular to said needle, passes under the needle and, once hooked the cord, is retracted while locking the cord by means of a lock.

15. The method according to claim 14, wherein, when the
20 cut in the last knotting ring has been performed, said coil is moved and replaced by a new coil to be laced, and the cord, locked by the harpoon by means of the lock, is automatically pulled and withdrawn from the self-locking knot.

16. The method according to claim 2 or 8, wherein said
25 cut in the last knotting ring is performed by means of a wire made incandescent by the passage of electric current.

17. The method according to claim 2 or 8, wherein, in the steps in which the needle is driven in a radial movement toward the inside of the coil, cord recovery means in said
30 supply means are made to intervene for maintaining tight the cord on the needle, and, in the steps in which the needle is

driven in a radial movement toward the outside of the coil, cord braking means are made to intervene to limit the cord delivery from said supply means.

18. An apparatus for automatically lacing and knotting,
5 by means of a cord, a generally toroidal coil of a dynamo-electric machine, said apparatus comprising:

cord supply means;

means for driving a lacing needle having a hook-shaped extremity, said driving means being capable of rotating said
10 needle around its own axis and of moving it radially and axially relatively to said coil for engaging said cord and pulling it radially in order to form interlaced lacing rings wrapping said coil; and

means for rotating said coil around its axis in
15 synchronism with the movement of said needle,

wherein said needle driving means being operable, upon completion of a lacing phase, to form a plurality of knotting rings in a chain-like arrangement on said end lacing terminal, by making the cord pass each time through a previously formed
20 knotting ring or through a last-formed lacing ring, respectively, when a first knotting ring is being formed,

wherein said needle driving means are arranged to pull the cord, during the formation of each knotting ring, to such an extent that said last-formed lacing ring and respectively
25 each knotting ring preceding a last knotting ring in the chain are individually closed on the knotting ring being formed,

whereby a chain of knot lockups forming a self-locking knot is obtained.

19. A fastening system for an end lacing terminal of a cord used for lacing a generally toroidal coil of a dynamo-electric machine by means of a lacing apparatus of the type comprising cord supply means, a lacing needle having a hook-shaped extremity and capable of rotating around its axis and of moving radially and axially relatively to said coil for engaging said cord and pulling it radially in order to form interlaced lacing rings wrapping said coil, and means for rotating said coil around its axis in synchronism with the movement of said needle, the system comprising:

a plurality of knotting rings in a chain-like arrangement on said end lacing terminal; and

a last-formed lacing ring and each knotting ring preceding a last knotting ring in the chain being individually closed into a knot lockup onto a first or respectively an immediately subsequent knotting ring,

whereby the system comprises a chain of knot lockups forming a self-locking knot.